To: 'Gusek, James'[jgusek@sovcon.com]
Cc: 'Bill Simon'[Personal Email/Ex. 6]; Way, Steven[way.steven@epa.gov]; 'Stover, Bruce'[Bruce.Stover@state.co.us]; 'Josselyn, Lee'[ljosselyn@sovcon.com]
From: Peter Butler
Sent: Tue 4/8/2014 6:13:34 PM
Subject: RE: Manganese treatment

Thanks very much for the information Jim and again thanks for your participation in the brainstorming effort.

ARSG has had numerous discussion about using limestone sand in the lower reaches of Cement Creek, but not up around the Gold King – have to think more about that location. One big concern people have with using limestone sand lower in Cement Creek is that the metal laden sediments could migrate eventually into the Animas and perhaps have undesirable environmental effects. There was also a concern that if application of sand ever stopped, there could be a substantial re-mobilizing of the metals from the bottom of Cement Creek as the pH dropped.

The idea of using pHoam in the mine workings is also interesting. We'll have to think about that some as well.

Peter Butler

970-259-0986

From: Gusek, James [mailto:jgusek@sovcon.com]
Sent: Tuesday, April 08, 2014 9:57 AM
To: Peter Butler
Cc: Bill Simon; Steve Way; Stover, Bruce; Josselyn, Lee
Subject: RE: Manganese treatment

Dear Peter,

The site I was referring to during the brainstorming meeting last week was the West Fork BCR site near Bunker, MO. Attached find two similar papers (somewhat dated) on this system.

What my co-author, Tom Wildeman (CSM) and I were wrestling with at the time (1992 to 1994) was the performance of an "accidental" passive system nearby – it was documented in this paper: Gale, N.L. and B.G. Wixson. 1979. "*Control of heavy metals in lead industry effluents by algae and other aquatic vegetation*". I don't have an electronic version of this; if you obtain one, I'd appreciate a copy. Gale and Wixson assumed it was the algae that accounted for the metal removal and they were partly right. The metal removal was likely a side-effect of the algae precipitating the MnO_2 on which the lead and zinc adsorbed. This phenomenon is predicated on first removing all of the dissolved iron (which could be done with an iron terrace at virtually any temperature/elevation). The attached IMWA paper from last summer summarizes the algae/MnO_2 adsorption process (along with three other processes) succinctly.

I had another thought on what might be done regarding the extraordinary acidity loading from the Gold King, especially during high flow events: **Limestone Sand.** This strategy, basically developed in the Appalachian Coal Fields, involves dumping truckloads of limestone sand on the banks of a stream and as storm water erodes the toe of the pile, limestone sand gets washed downstream, raising the pH. The sand bouncing along the channel erodes any iron oxyhydroxide coatings to yield fresh surfaces. Check out: Brown, 2005 (attached). In Brown, the first application was equal to twice the annual acidity load for a given watershed (or sub-watershed); subsequent applications were equal to the estimated annual acidity loads. For the ARSG's situation, **once the iron and acidity is removed, MnO_2 deposition (in portions of Cement Creek) and associated zinc sequestration should follow.** Sovereign would be pleased to participate in the design and implementation of this technology if you decide to pursue this option objectively.

Also, you must be aware of the foam work that Golder did last fall. I was waiting for Tom Rutkowski to bring it up at the brainstorming session because Golder has applied for a patent for this technology. I was the inventor of this concept (white paper attached) when I was with Golder. I believe that this may be an economical and feasible method to deliver "source control reagents" to target ARD-producing zones in the mines. In the case of the Gold King Mine, this would involve injecting a low water content pHoam that carries neutralizing powdered limestone into the upper un-flooded workings. We can discuss the obvious advantages of doing this further at your convenience.

ARSG may be interested in considering a demonstration size application to see what this technology can do. With the patent still pending (to my knowledge), there has been some reluctance by Golder to apply this technology. There is also some fear in the potential risk that pHoam deployment may work too well and mobilize beyond its target areas. Having said that, Sovereign would be willing to conduct field tests using this concept on a smaller scale, perhaps in the Red and Bonita Mine while it's still open.

We believe we could obtain pHoaming agent from Aerix Industries, the co-patent applicant with Golder or from alternative sources because the patent has yet to be awarded (and it may never be). Involving Golder at this point is optional.

Thanks again for the invite to the brainstorming session and for picking up the dinner tab afterward. I had a nice time and got to meet some interesting people.

Kind regards,

Jim

From: Peter Butler [mailto:Personal Email/Ex. 6]
Sent: Monday, April 07, 2014 2:27 PM
To: Gusek, James
Cc: Bill Simon
Subject: Manganese treatment

Jim – First, thank you again for participating in our brainstorming session last week.

Second, you talked some about using manganese to treat AMD mentioned a paper on the Black

River. Do you have a copy or a reference to the paper so we could understand the concept better?

Thanks.

Peter Butler

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